Core-SOL Modelling of ELM mitigation at JET
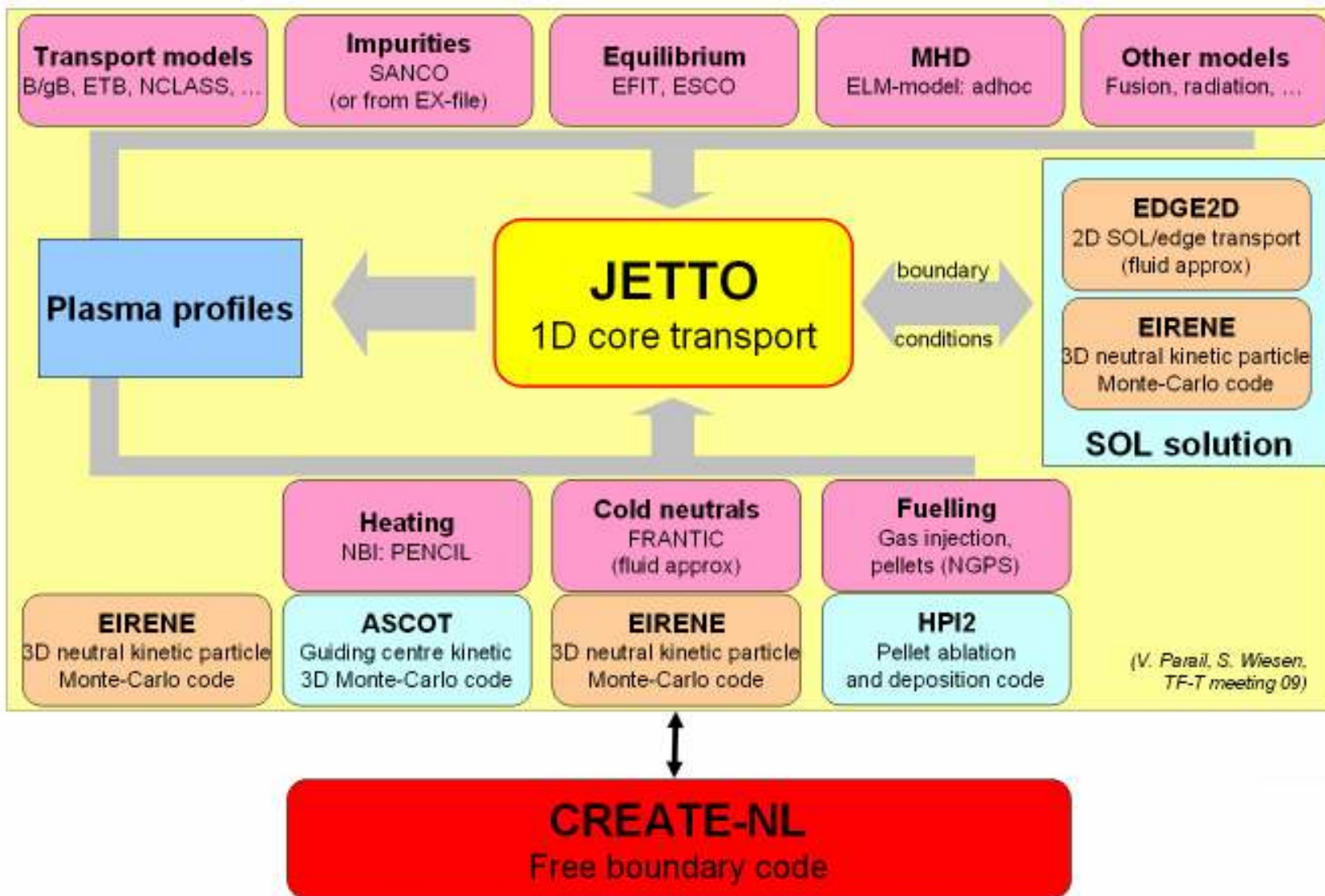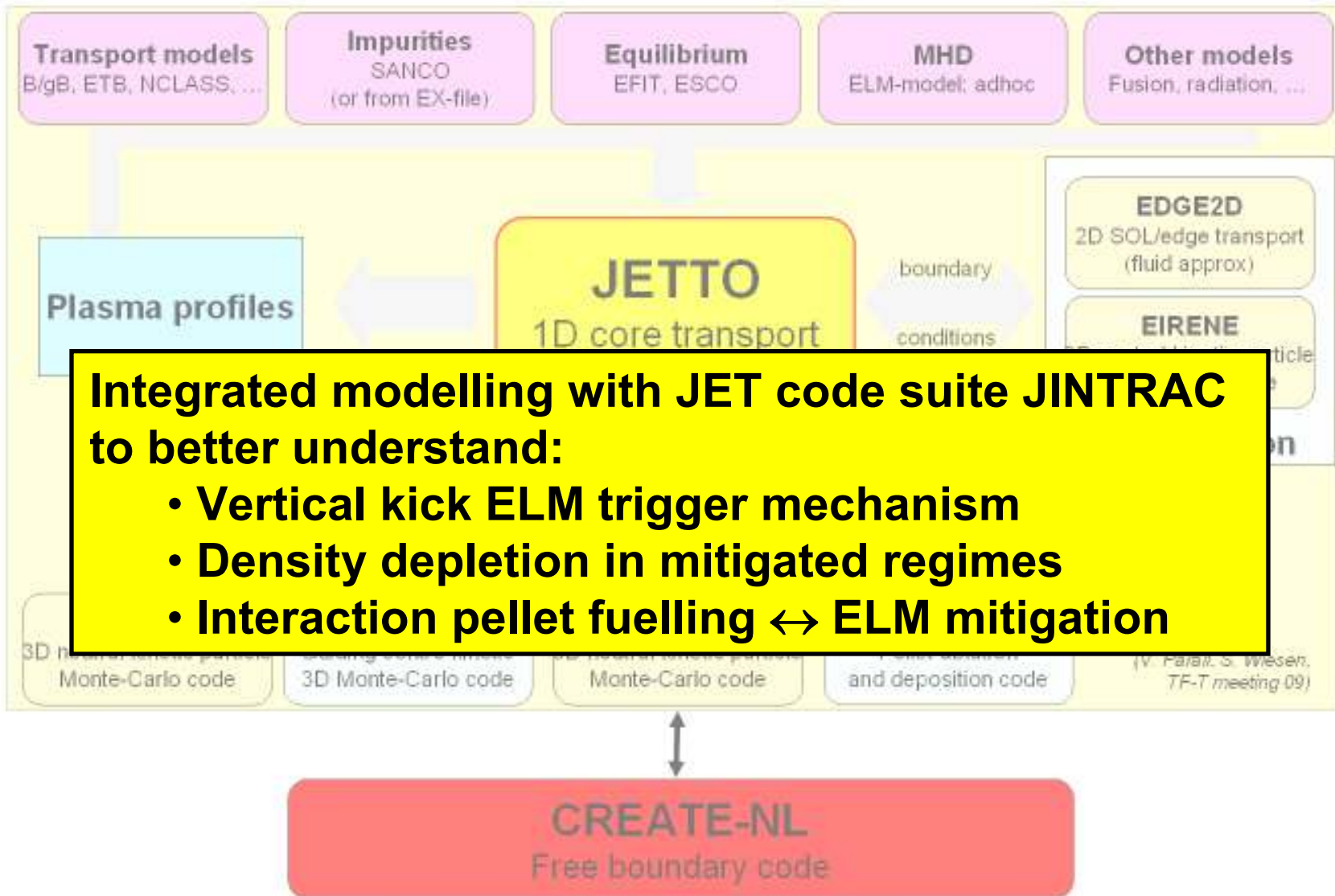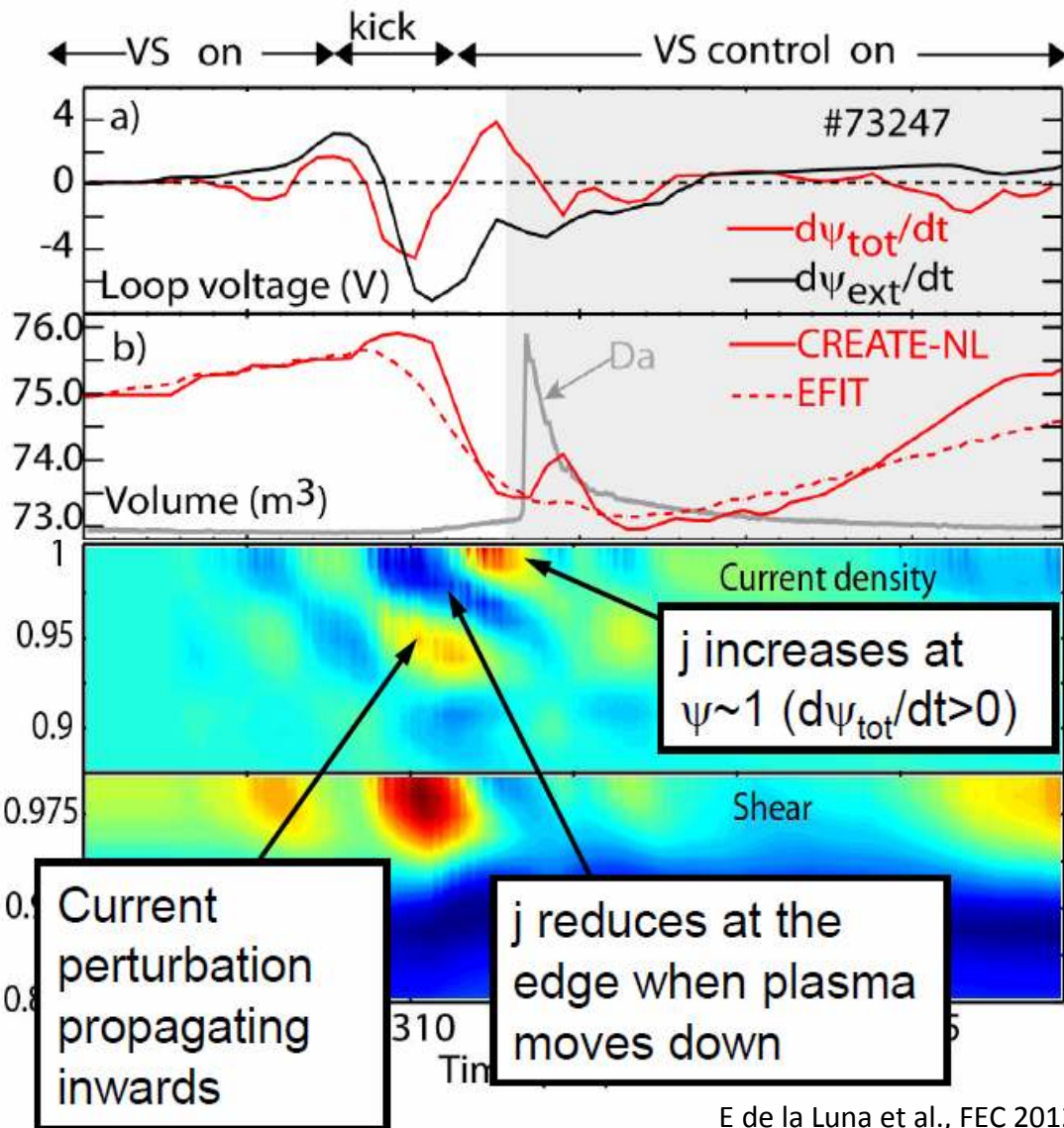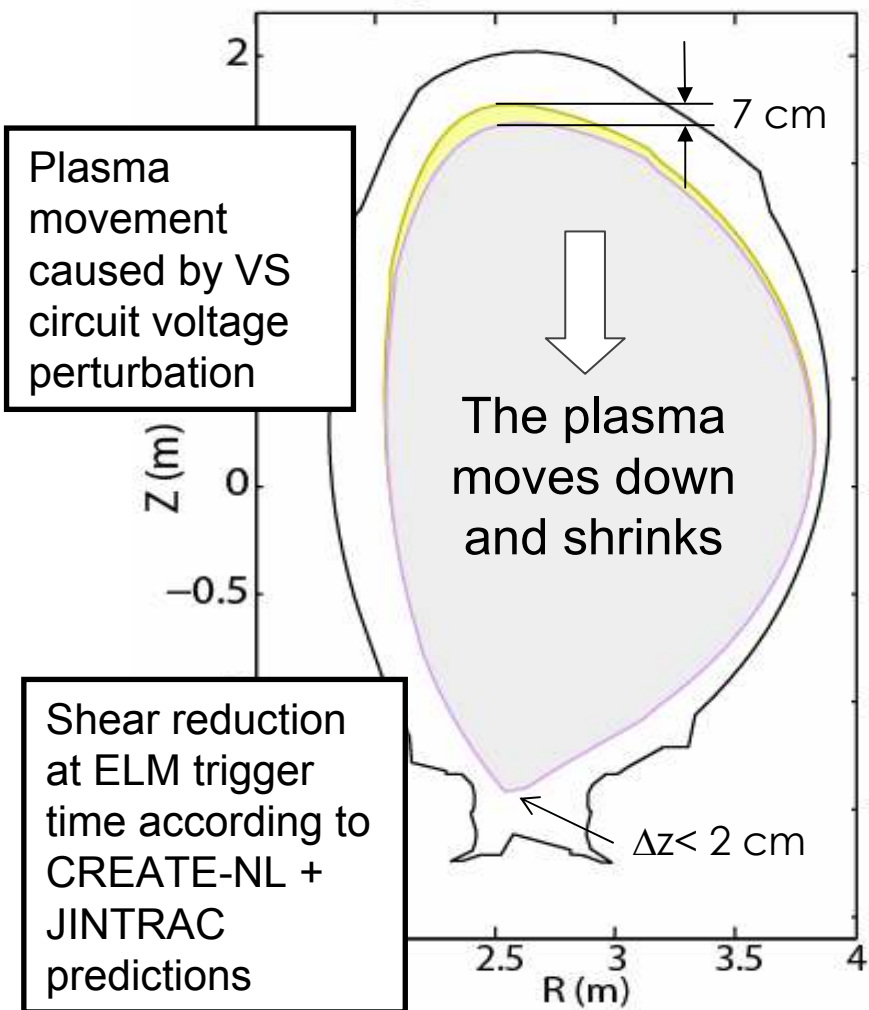
F Koechl, R Albanese, R Ambrosino, G Corrigan, L Garzotti, H-S Kim, J Lönnroth, P T Lang, E de la Luna, M Mattei, F Maviglia, D C McDonald, V Parail, F Rimini, G Saibene, E R Solano, M Valovič, I Voitsekhovitch, A Webster, S Wiesen, JET EFDA contr. & ITM-TF ISM Group.

2nd ISM WS, CEA, Cadarache, 6.6.2013

(V. Parail, S. Wiesen, TF-T meeting 09)

Integrated modelling with JET code suite JINTRAC to better understand:
- Vertical kick ELM trigger mechanism
- Density depletion in mitigated regimes
- Interaction pellet fuelling $\leftrightarrow$ ELM mitigation

#77640 @ 59.29 s

Plasma movement caused by VS circuit voltage perturbation

The plasma moves down and shrinks

7 cm

Δz< 2 cm

Shear reduction at ELM trigger time according to CREATE-NL + JINTRAC predictions

VS on — kick — VS control on

a) Loop voltage (V)   #73247

$d\psi_{tot}/dt$
$d\psi_{ext}/dt$

b) Volume (m^3)

CREATE-NL
EFIT

Da

Current density

j increases at $\psi \sim 1$ ($d\psi_{tot}/dt > 0$)

Shear

Current perturbation propagating inwards

j reduces at the edge when plasma moves down

E de la Luna et al., FEC 2012

**Reduction in density at higher ELM frequency,
with mild degradation in confinement:**
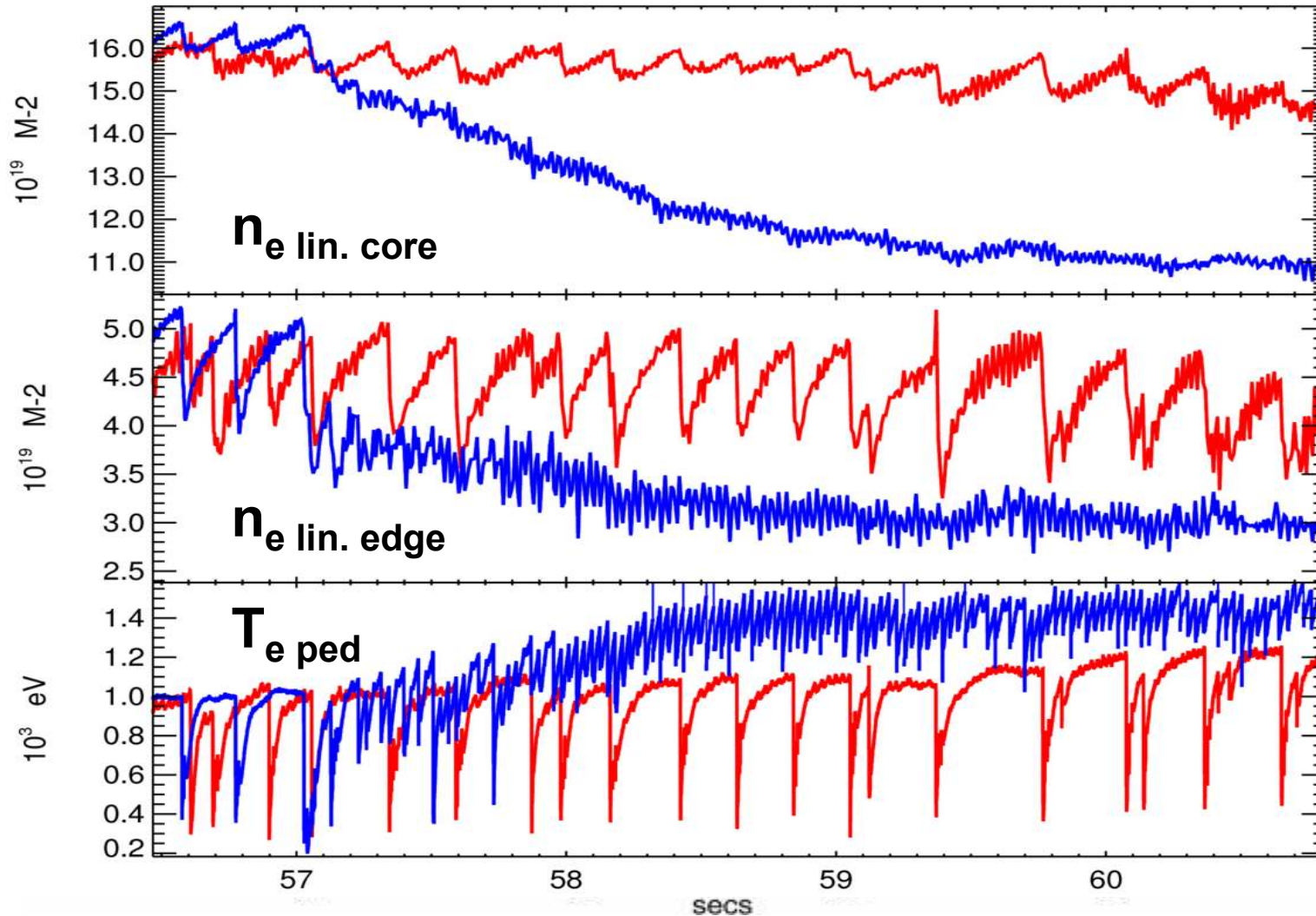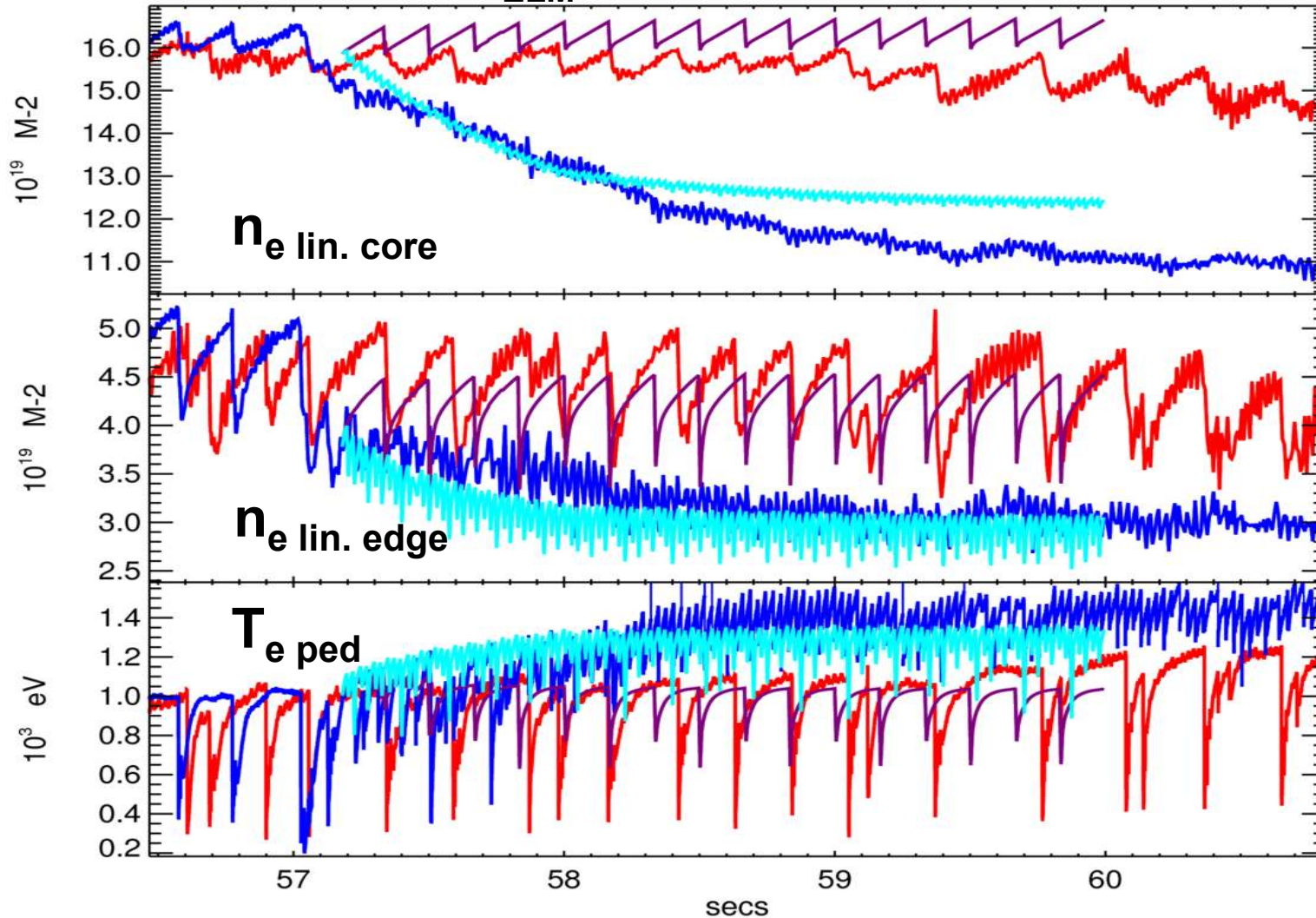

$f_{ELM} \approx 6$ Hz,
experiment

$f_{ELM} \approx 40$ Hz,
experiment

Experimental trends can be reproduced with JINTRAC, same simulation conditions except for f_{ELM} and ELM amplitude (adjusted to ΔW_{ELM}):

$f_{ELM} \approx 6$ Hz, experiment

$f_{ELM} \approx 6$ Hz, simulation
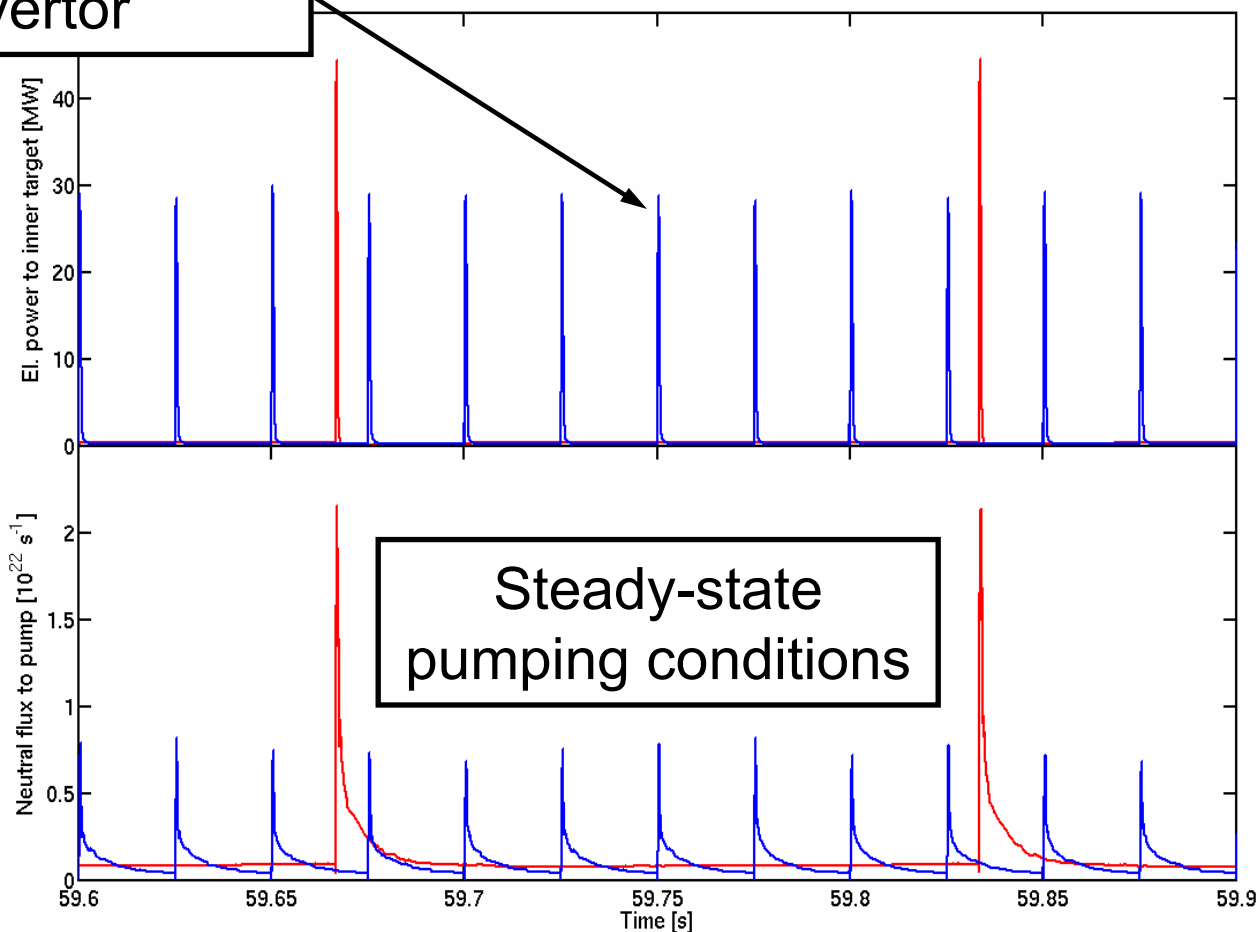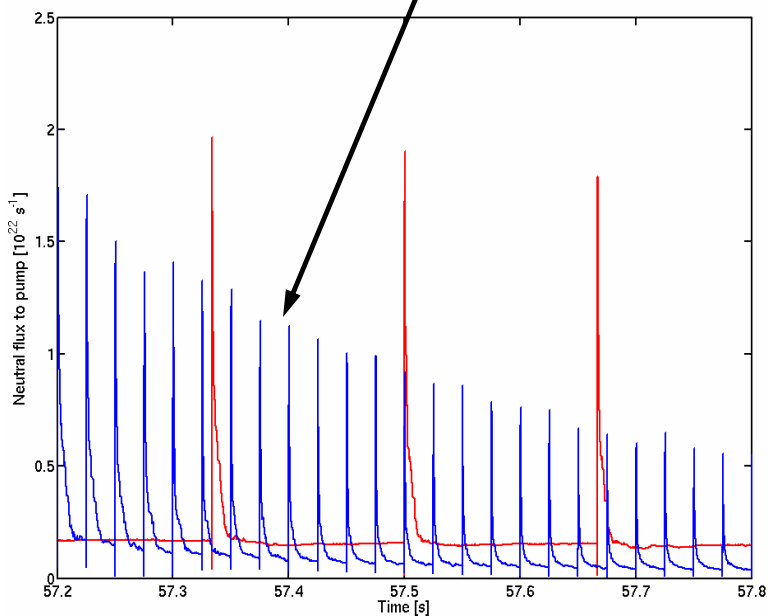
$f_{ELM} \approx 40$ Hz, experiment

$f_{ELM} \approx 40$ Hz, simulation

Electron power to inner target / pumped neutrals:

f_{ELM} = 6 Hz, simulation
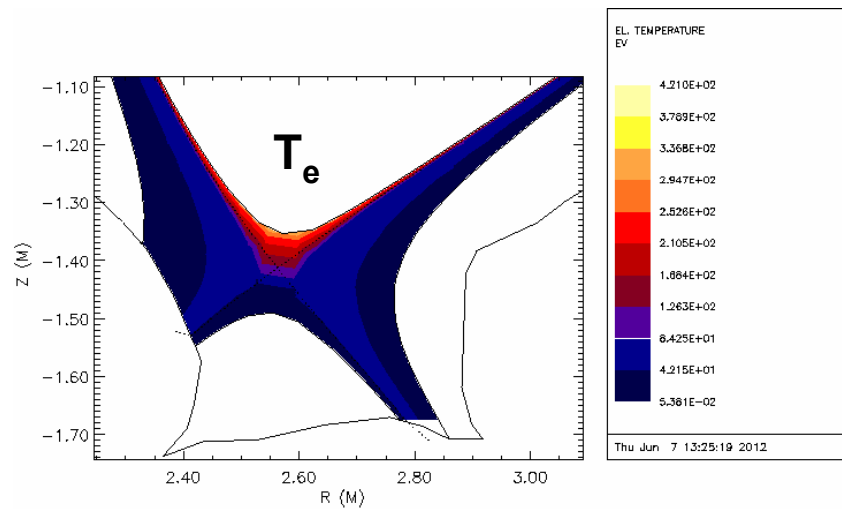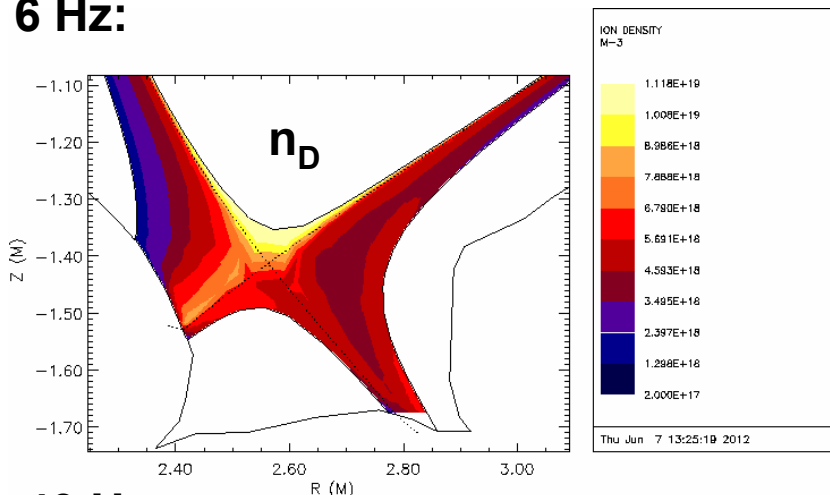f_{ELM} = 40 Hz, simulation

Mitigated ELM impact
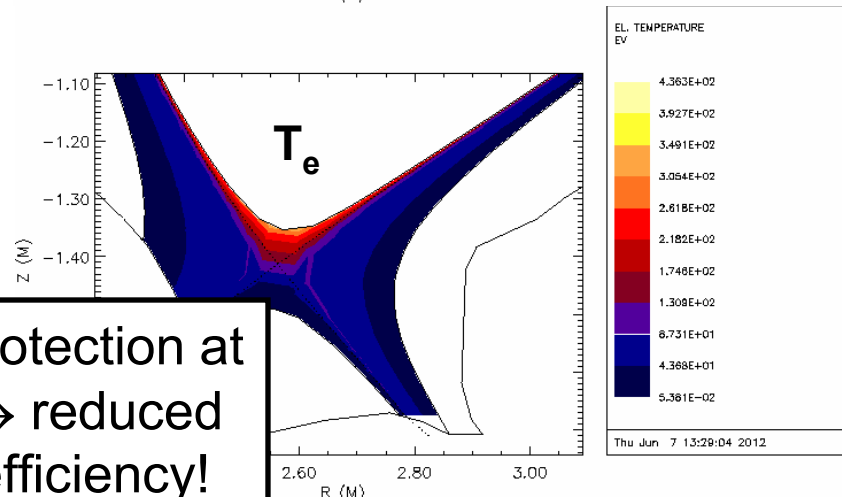on divertor
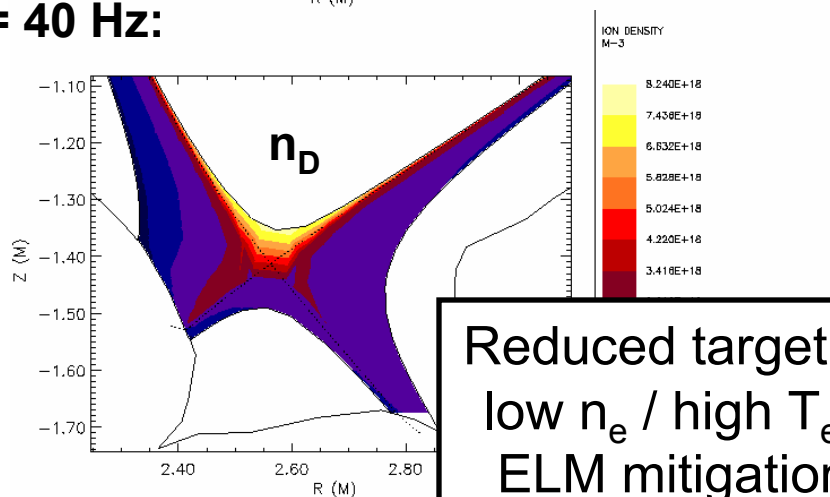
Enhanced pumping until
lower n_e level is reached

Steady-state
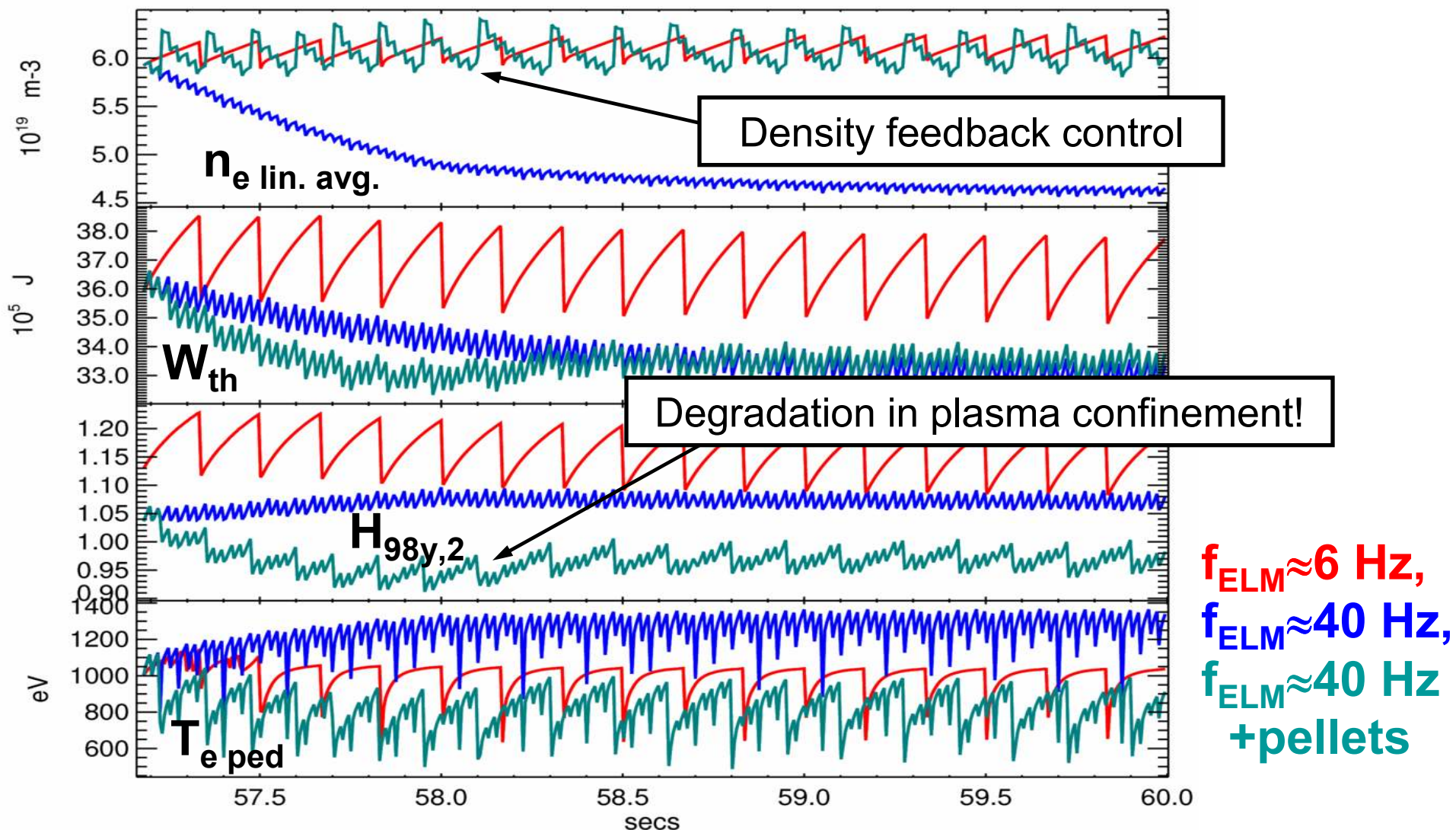pumping conditions

SOL contour plots (t ~ 60.0s):

f_{ELM} = 6 Hz:

f_{ELM} = 40 Hz:

Reduced target protection at low n_e / high T_e → reduced ELM mitigation efficiency!

JINTRAC simulations, density maintained by pellet injection:

Density feedback control

Degradation in plasma confinement!

$f_{ELM} \approx 6$ Hz,
$f_{ELM} \approx 40$ Hz,
$f_{ELM} \approx 40$ Hz
+pellets

Summary:

Summary:

- Kick-triggered ELMs can be reproduced assuming peeling mode (current driven) instabilities (pressure perturbation too small to reach critical gradient for natural ELMs).
- Shear modification due to combination of current reduction close to the edge + induced current close to top of pedestal may be responsible for ELM triggering and could explain ELM trigger time delay.
- Density depletion in mitigated regime appears to be natural consequence of different location of heat and particle sources and enhanced pumping efficiency; "mitigated" ELM mitigation due to change in SOL conditions.
- Pellet injection might help to recover initial density, but leads to a degradation in confinement.